US009926821B2

(12) **United States Patent**
Yamada et al.

(10) **Patent No.: US 9,926,821 B2**
(45) **Date of Patent: Mar. 27, 2018**

(54) **CYLINDER LUBRICATION SYSTEM FOR TWO-STROKE ENGINE**

(71) Applicant: **HONDA MOTOR CO., LTD.**, Tokyo (JP)

(72) Inventors: **Yoshikazu Yamada**, Saitama (JP); **Mashu Kurata**, Saitama (JP)

(73) Assignee: **HONDA MOTOR CO., LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 118 days.

(21) Appl. No.: **14/514,520**

(22) Filed: **Oct. 15, 2014**

(65) **Prior Publication Data**

US 2015/0184563 A1 Jul. 2, 2015

(30) **Foreign Application Priority Data**

Dec. 27, 2013 (JP) 2013-271037

(51) **Int. Cl.**
F01M 11/02 (2006.01)
F01M 1/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F01M 11/02*** (2013.01); ***F01L 1/06*** (2013.01); ***F01L 1/08*** (2013.01); ***F01L 1/10*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . F01M 1/06; F01M 1/08; F01M 11/02; F01M 2001/083; F01M 2011/022;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,280,455 A * 7/1981 Yamaguchi .... F01M 1/08 123/196 M
5,570,668 A * 11/1996 Hsu F01M 1/08 123/193.2
(Continued)

FOREIGN PATENT DOCUMENTS

JP 54117844 A * 9/1979 .... F01M 1/06
JP 55025684 U * 2/1980 .... F02F 3/00
(Continued)

OTHER PUBLICATIONS

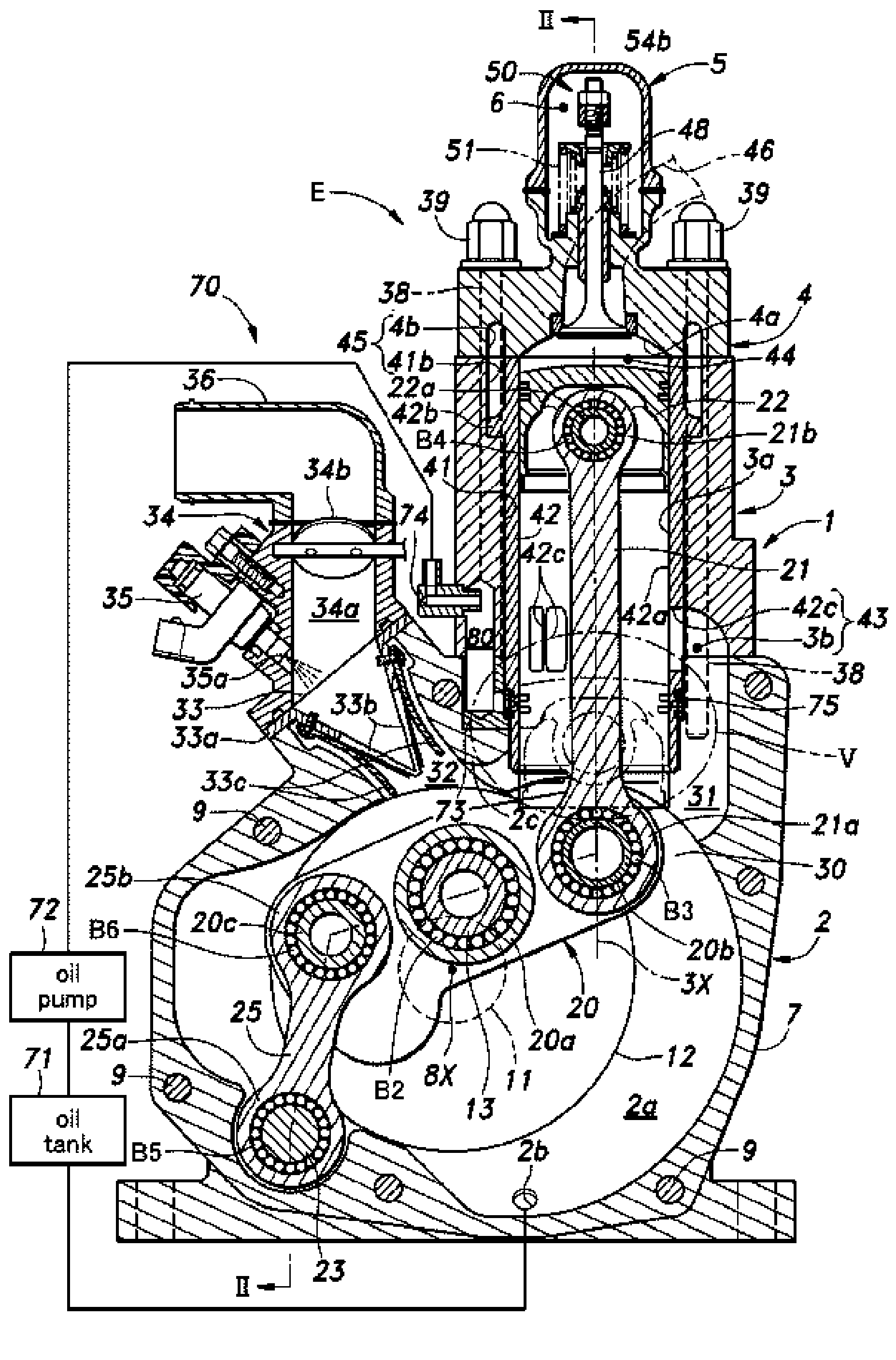
English machine translation from IP.com of JP 2979007.*
(Continued)

Primary Examiner — Jacob Amick
Assistant Examiner — Michael A Kessler
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

In a cylinder lubrication system for a two-stroke engine, a plurality of lubricating oil supply openings (**78**) open out in the inner circumferential surface of the cylinder (**42**) at a point lower than a top ring (**22***b*) of a piston (**22**) located at a bottom dead center. The lubricating oil supply openings are configured to provide a larger amount of lubricating oil in the thrust side and anti-thrust side of the cylinder than in a remaining part of the cylinder. Thereby, the consumption of lubricating oil and the emission of undesired substances can be minimized while providing an optimum lubrication of the sliding part between the piston and the cylinder.

7 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

F02F 7/00	(2006.01)
F01L 1/06	(2006.01)
F01L 1/08	(2006.01)
F01L 1/10	(2006.01)
F01L 1/12	(2006.01)
F01L 1/14	(2006.01)
F01L 1/18	(2006.01)
F01L 3/20	(2006.01)
F01M 1/08	(2006.01)
F02F 1/22	(2006.01)
F02F 1/20	(2006.01)
F02B 75/32	(2006.01)
F02B 75/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F01L 1/12*** (2013.01); ***F01L 1/146*** (2013.01); ***F01L 1/18*** (2013.01); ***F01L 3/205*** (2013.01); ***F01M 1/02*** (2013.01); ***F01M 1/08*** (2013.01); ***F02F 7/0036*** (2013.01); *F01L 2105/00* (2013.01); *F01M 2001/083* (2013.01); *F01M 2011/022* (2013.01); *F02B 75/32* (2013.01); *F02B 2075/025* (2013.01); *F02F 1/20* (2013.01); *F02F 1/22* (2013.01)

(58) **Field of Classification Search**

CPC F01M 3/04; F02F 1/20; F02F 1/22; F02F 7/0036; F01B 11/00; F01B 11/02

USPC .... 184/6.8; 123/196 R, 196 M

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,581,563	B2	6/2003	Uneta	
7,104,240	B1 *	9/2006	Vuk	F02F 1/20 123/193.2
7,685,991	B2 *	3/2010	Cumming	F02F 1/20 123/305
9,695,738	B2 *	7/2017	Kurata	F02F 1/22
2002/0011231	A1	1/2002	Uneta	
2009/0013866	A1 *	1/2009	Kariya	F16J 9/068 92/172

FOREIGN PATENT DOCUMENTS

JP	62067261	A	*	3/1987	F16J 1/08
JP	2979007	B2	*	11/1999	F01M 1/06
JP	2002-081305	A		3/2002	
JP	2002-529648	A		9/2002	
JP	2003-286816	A		10/2003	
JP	2004-144014	A		5/2004	

OTHER PUBLICATIONS

English machine translation of JP 55025684 U.*

Human Translation of JP 55-025684 U.*

Japanese Office Action dated Jul. 19, 2016, issued in corresponding Japanese Patent Application No. 2013-271037, with English translation.

* cited by examiner

Fig. 1

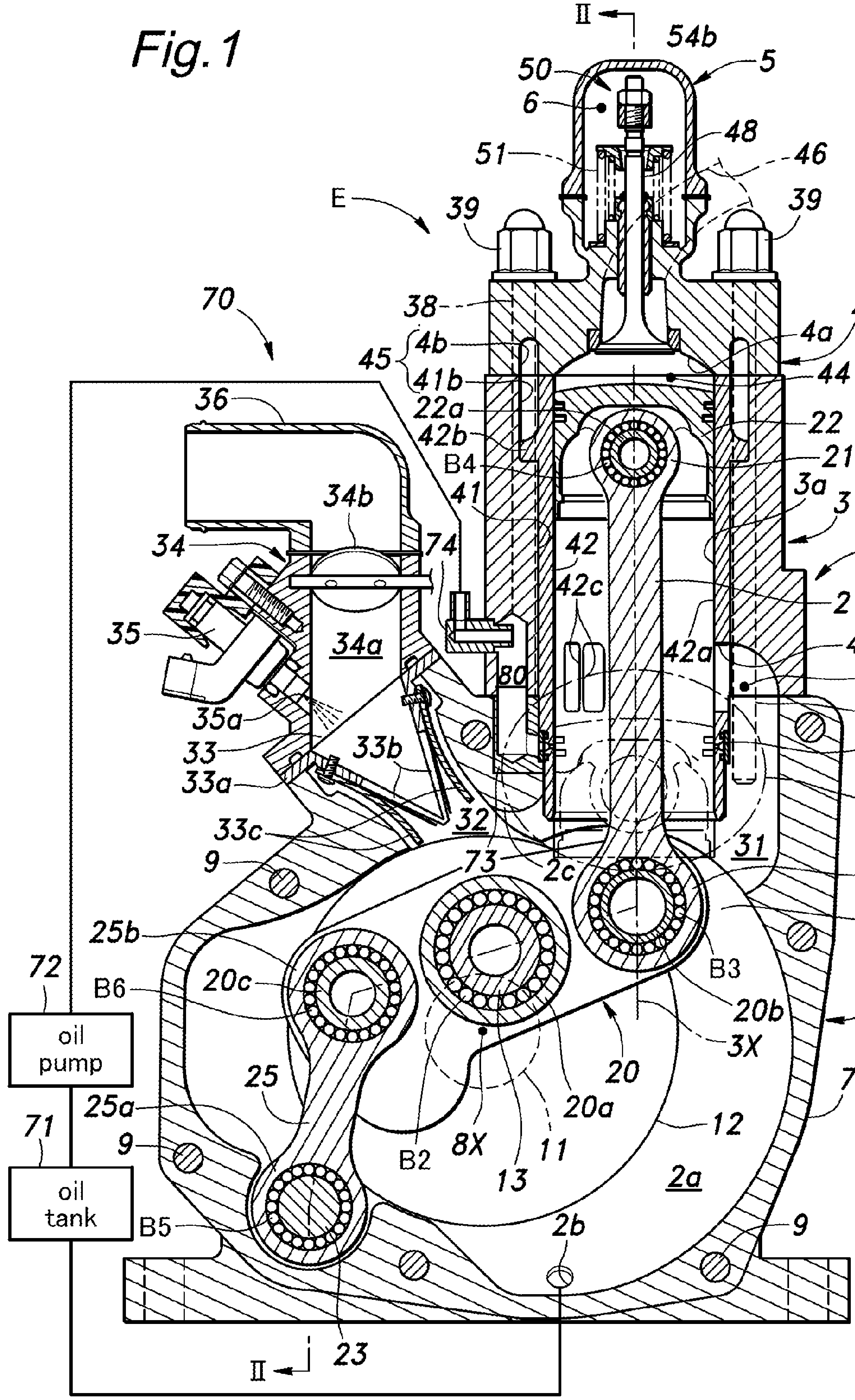

II
54b
50
5
6
48
51
46
E
39
39
70
38
4
45
4b
4a
41b
44
36
22a
22
42b
B4
21b
34b
41
3a
3
34
74
42
1
42c
35
34a
21
42a
42c
43
80
3b
35a
38
33
33b
75
33a
V
32
33c
31
9
73
2c
21a
30
25b
72
B3
oil pump
20c
B6
20b
2
3X
20
25
7
25a
20a
12
71
9
B2
8X
11
oil tank
13
2a
B5
2b
9
23
II

Fig.2

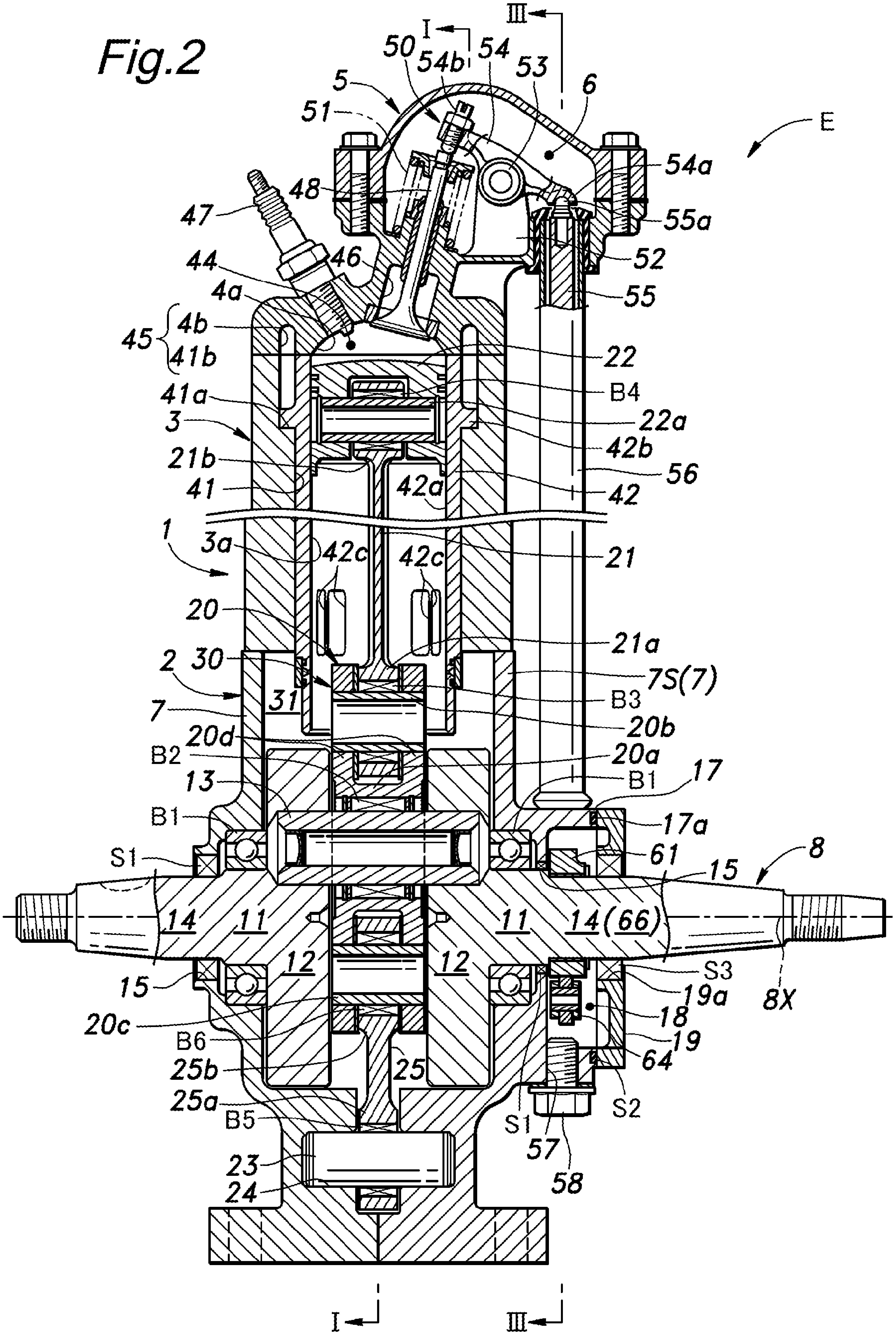

I
III
50
54b
54
53
6
5
51
E
54a
48
55a
47
52
44
46
55
4a
4b
45
41b
22
41a
B4
3
22a
42b
21b
56
41
42a
42
1
3a
42c
42c
21
20
21a
2
30
7S(7)
31
B3
7
20b
20d
B2
20a
13
B1
17
B1
17a
S1
61
8
15
14
11
11
14(66)
12
12
S3
15
19a
8X
20c
18
B6
19
64
25b
25
25a
S2
B5
S1
57
23
58
24
I
III

Fig.3

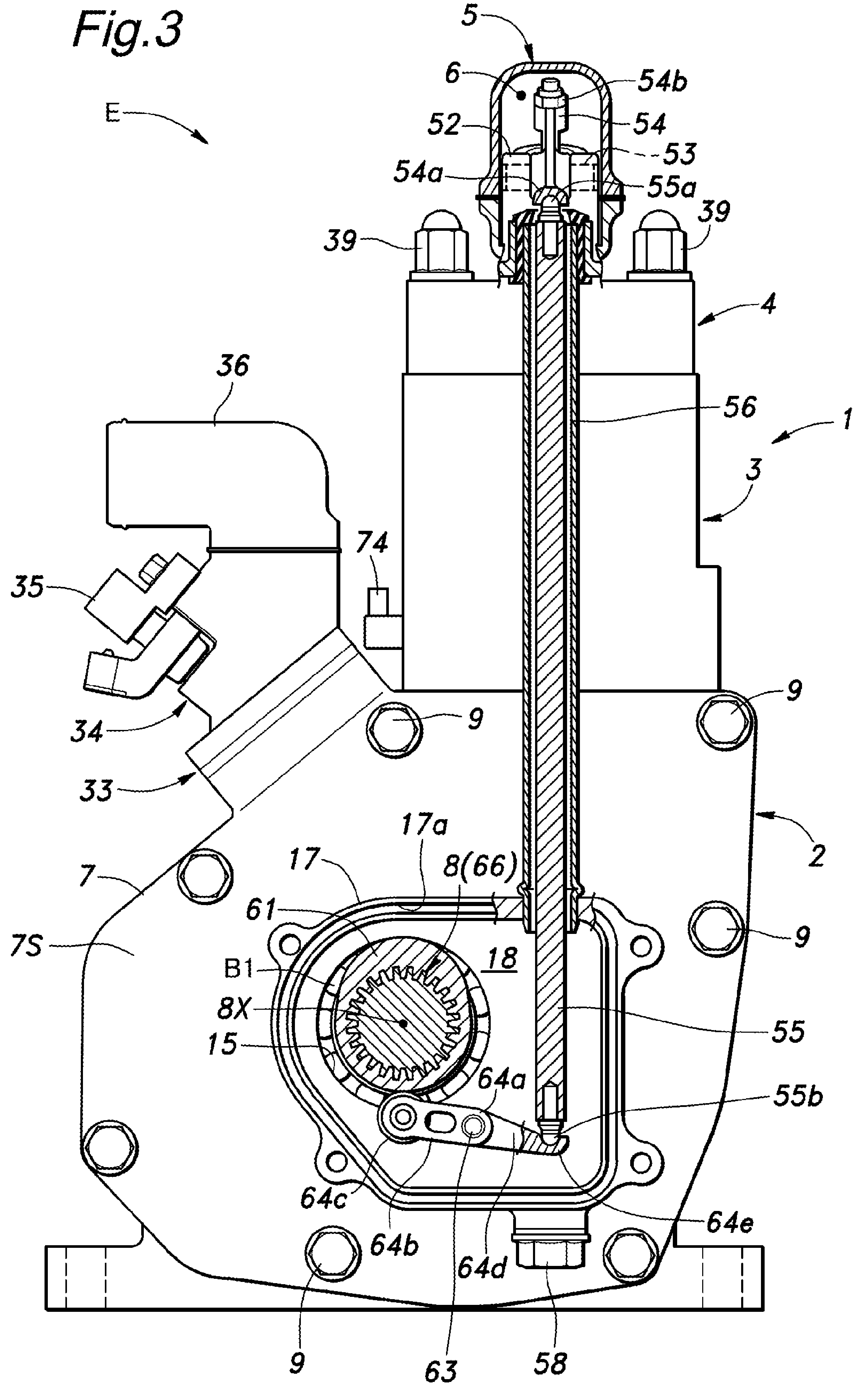

5
6
54b
52
54
53
54a
55a
39
39
4
E
36
56
1
3
74
35
34
9
9
33
2
17a
7
17
8(66)
61
9
7S
18
B1
8X
55
15
64a
55b
64c
64b
64d
64e
9
63
58

Fig.4

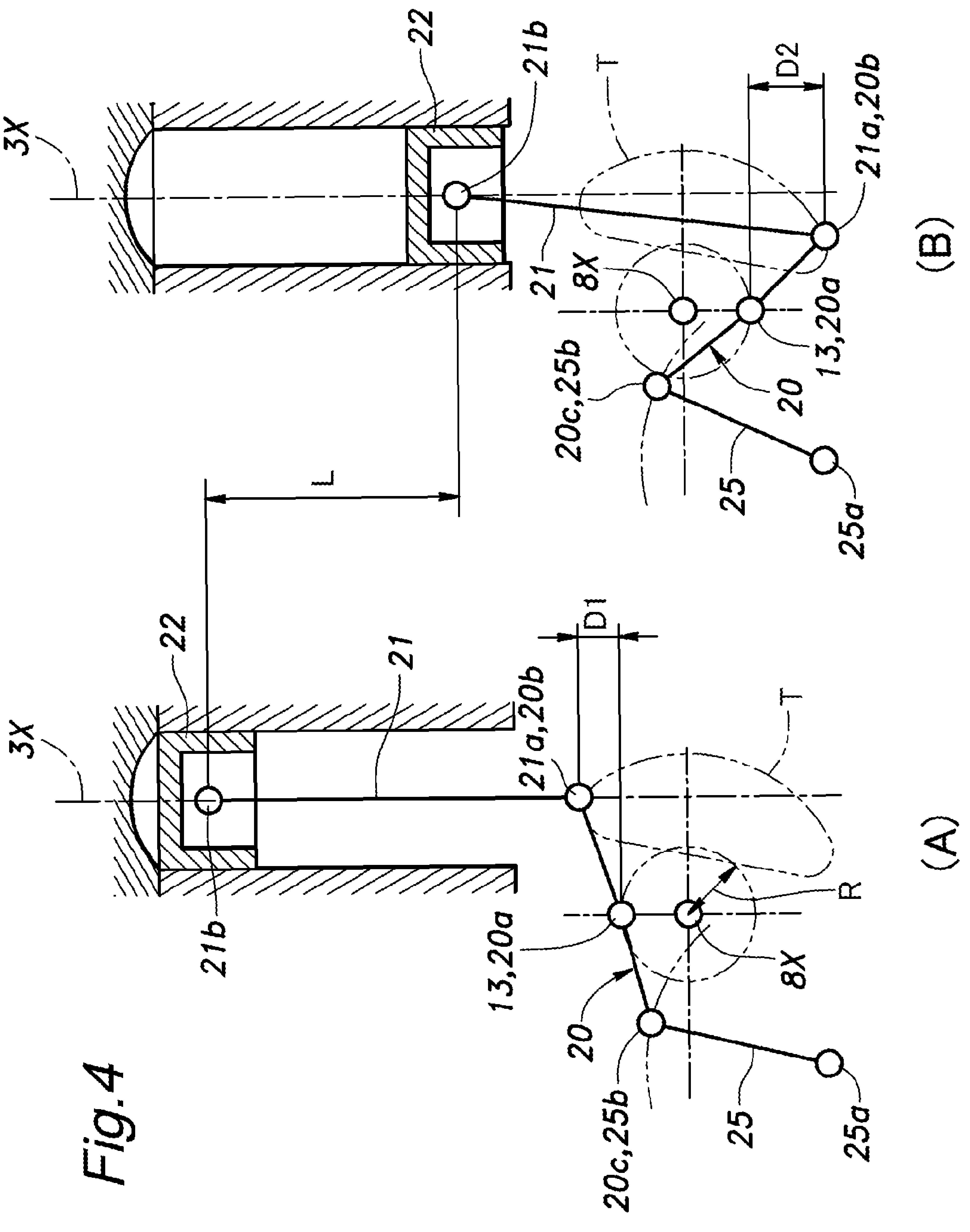

3X
22
21b
21
21a,20b
D1
T
R
13,20a
8X
20
20c,25b
25
25a
(A)
L
3X
22
21b
T
D2
21a,20b
21
8X
13,20a
20
20c,25b
25
25a
(B)

Fig.5

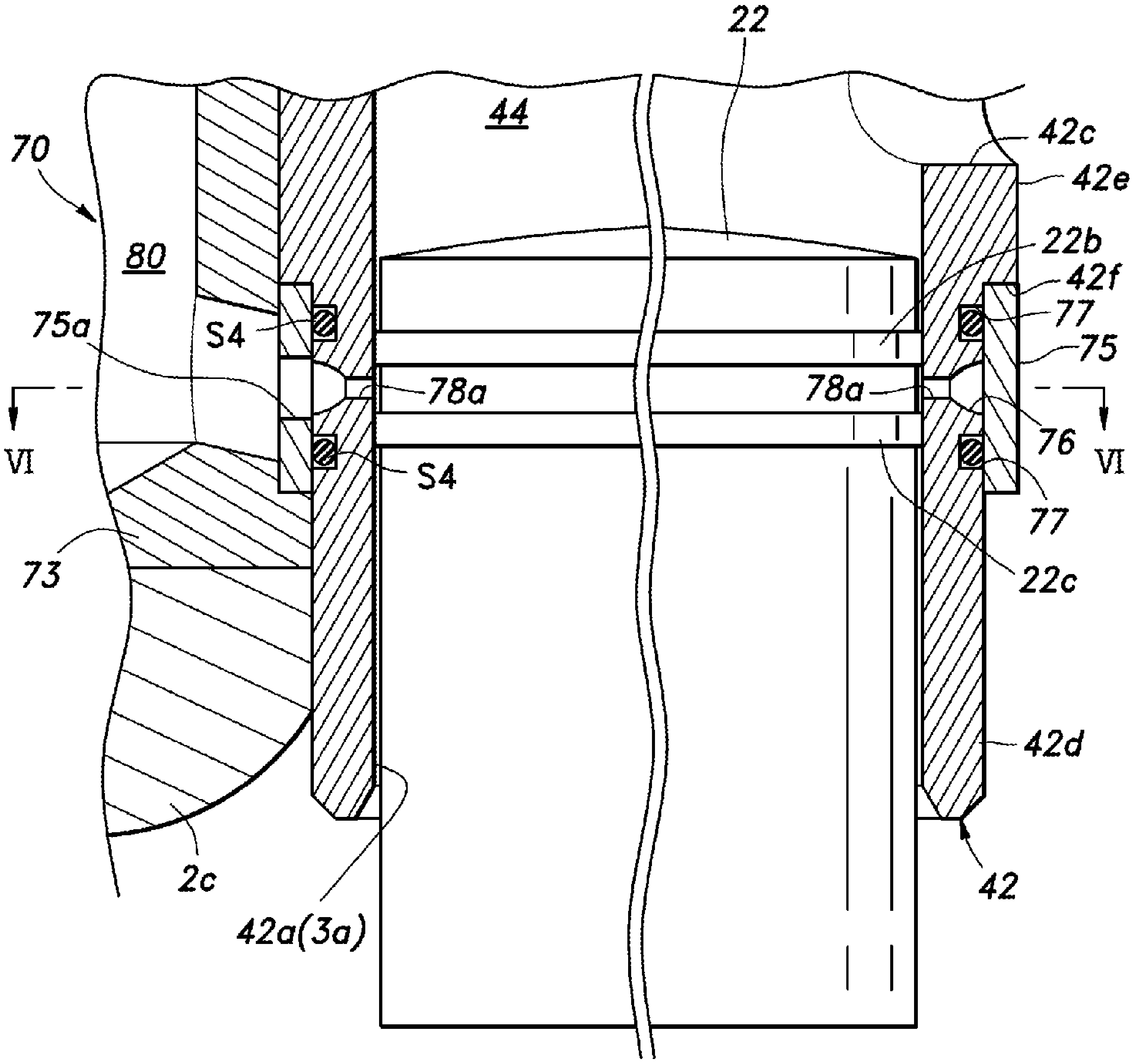

22
44
70
80
42c
42e
22b
42f
77
75
75a
S4
78a
78a
VI
VI
76
S4
77
22c
73
42d
2c
42a(3a)
42

Fig.6

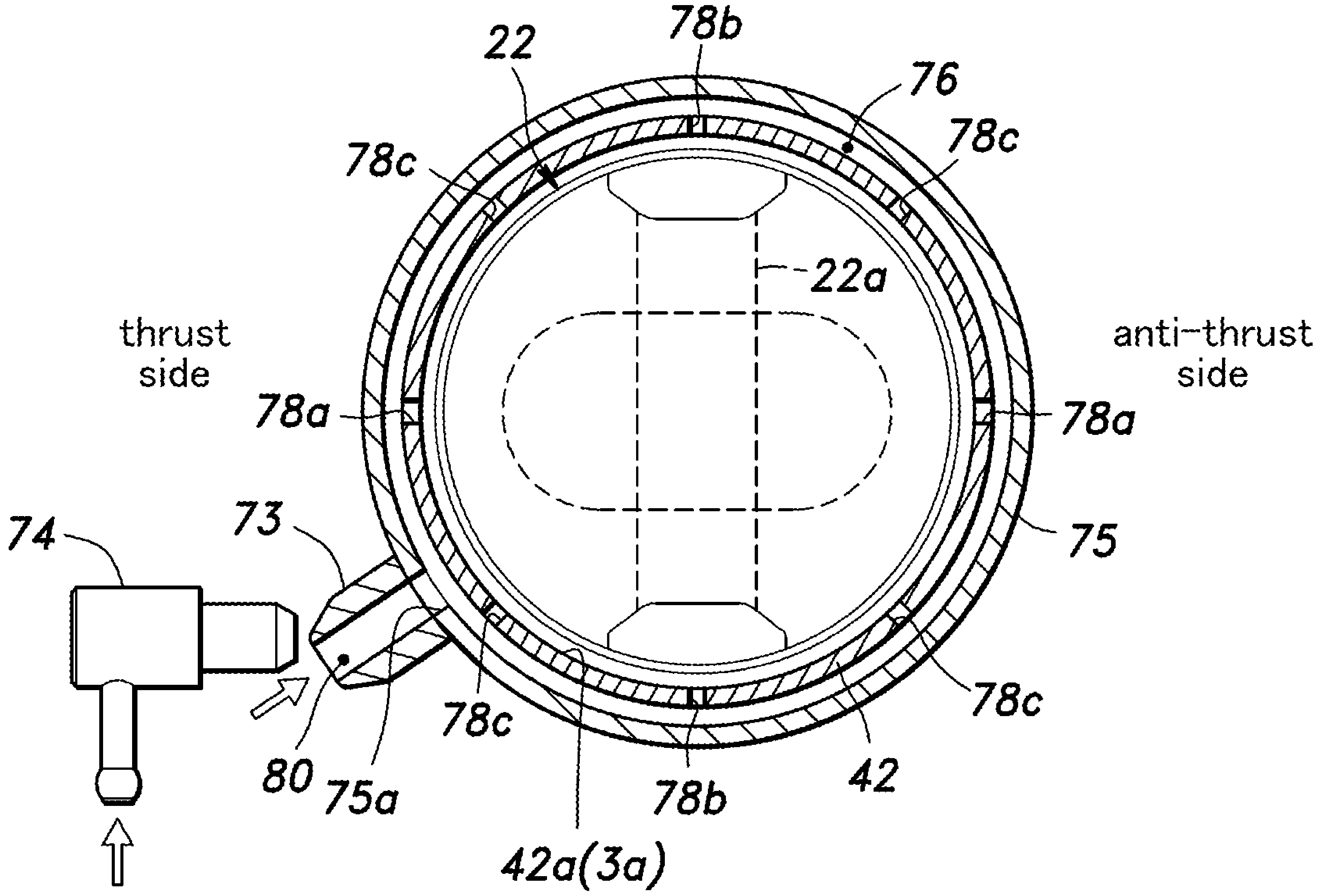

22
78b
76
78c
78c
22a
thrust side
anti-thrust side
78a
78a
74
73
75
80
75a
78c
78b
42
78c
42a(3a)

Fig.7

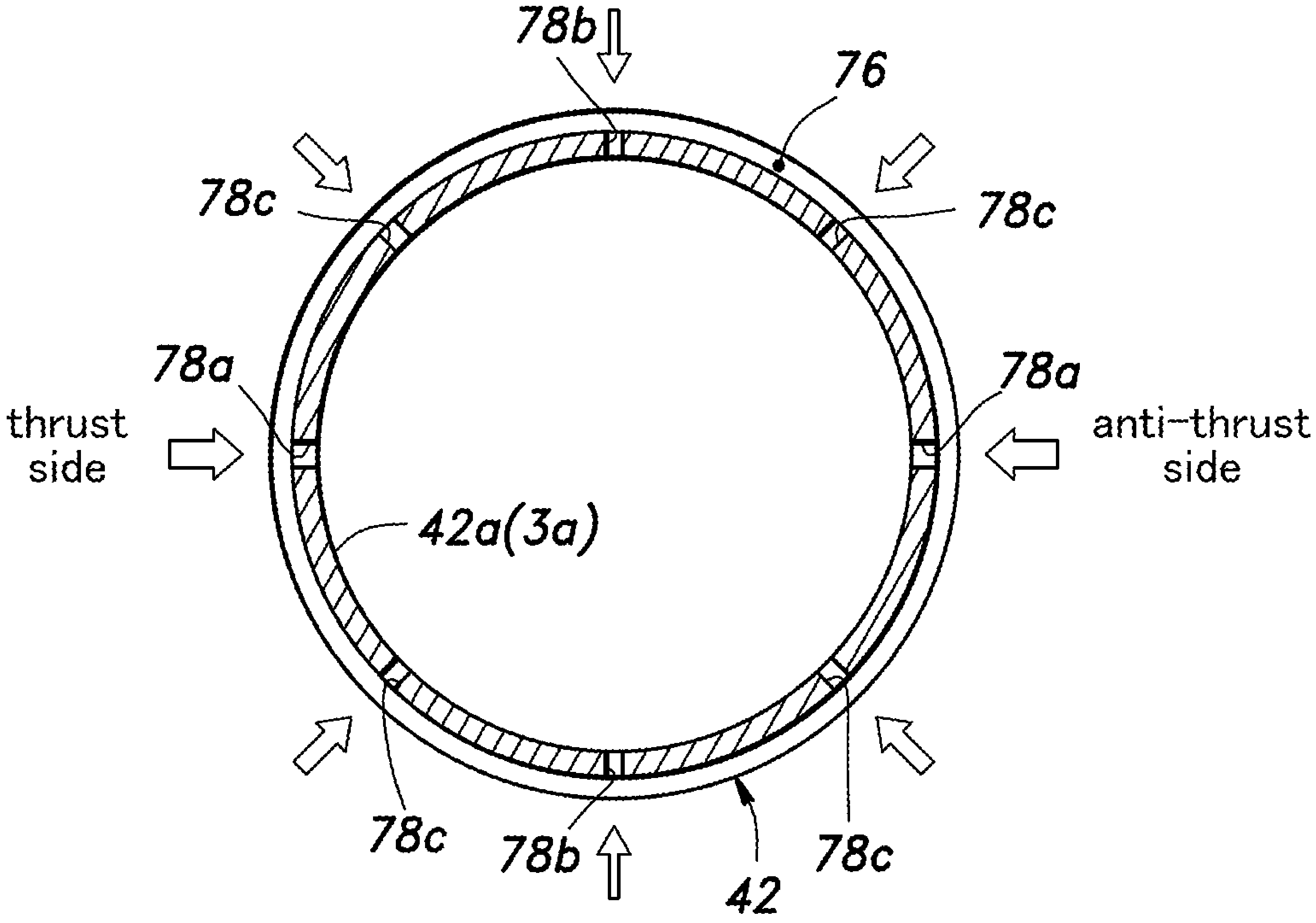

78b
76
78c
78c
78a
78a
thrust side
anti-thrust side
42a(3a)
78c
78b
78c
42

Fig.8

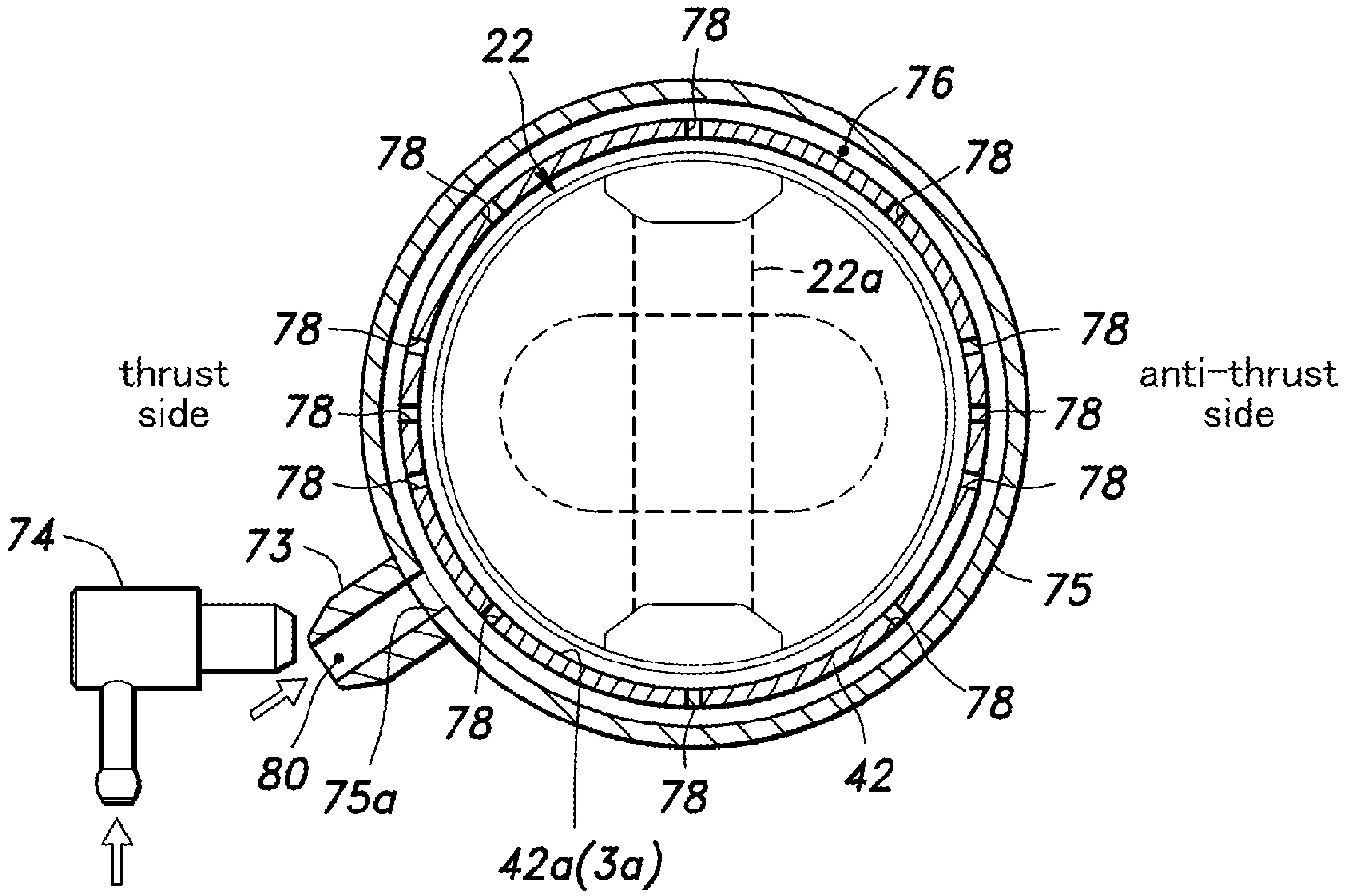

78
22
76
78
78
22a
78
78
thrust side
78
78
anti-thrust side
78
78
74
73
75
78
78
80
75a
78
42
42a(3a)

Fig.9

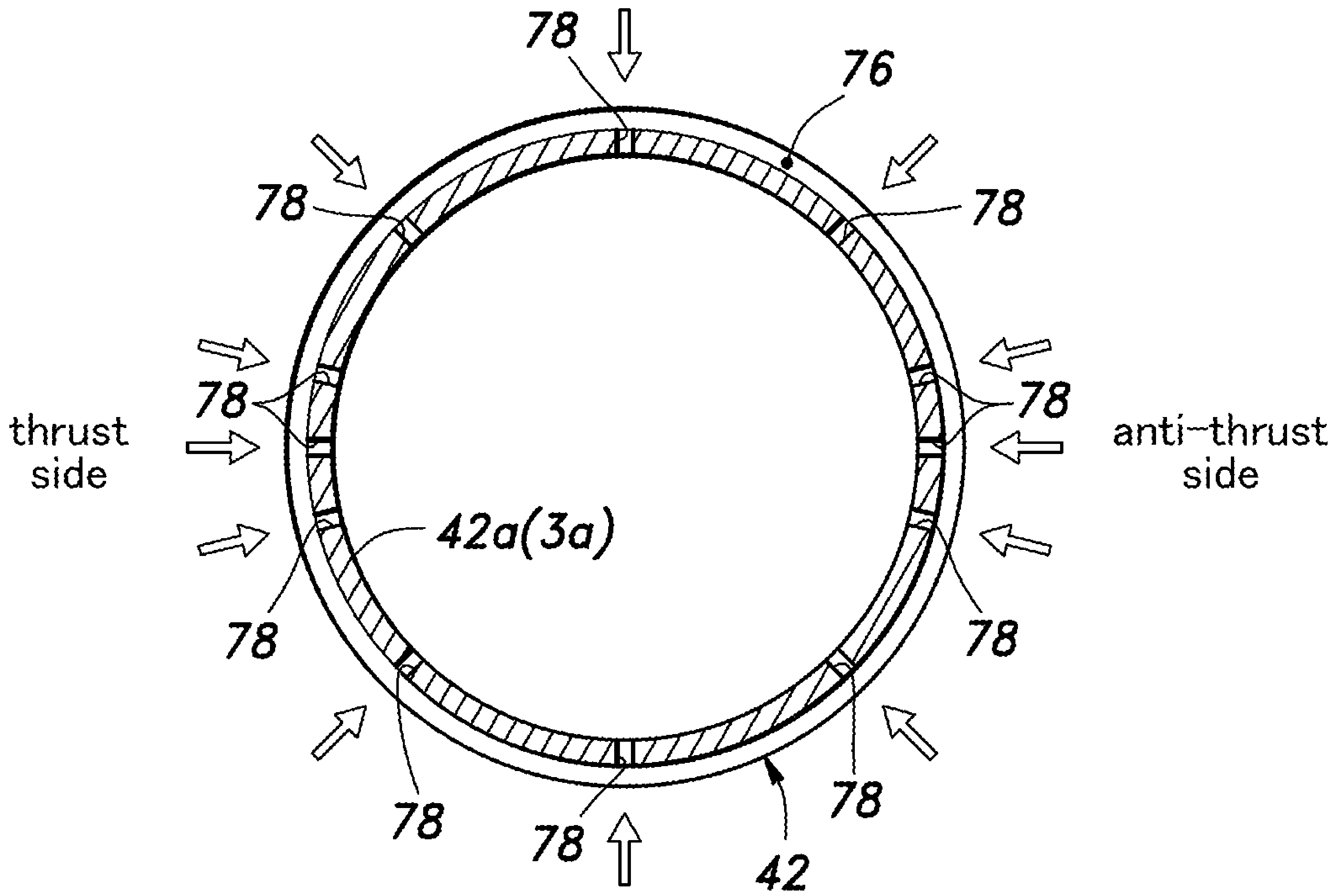
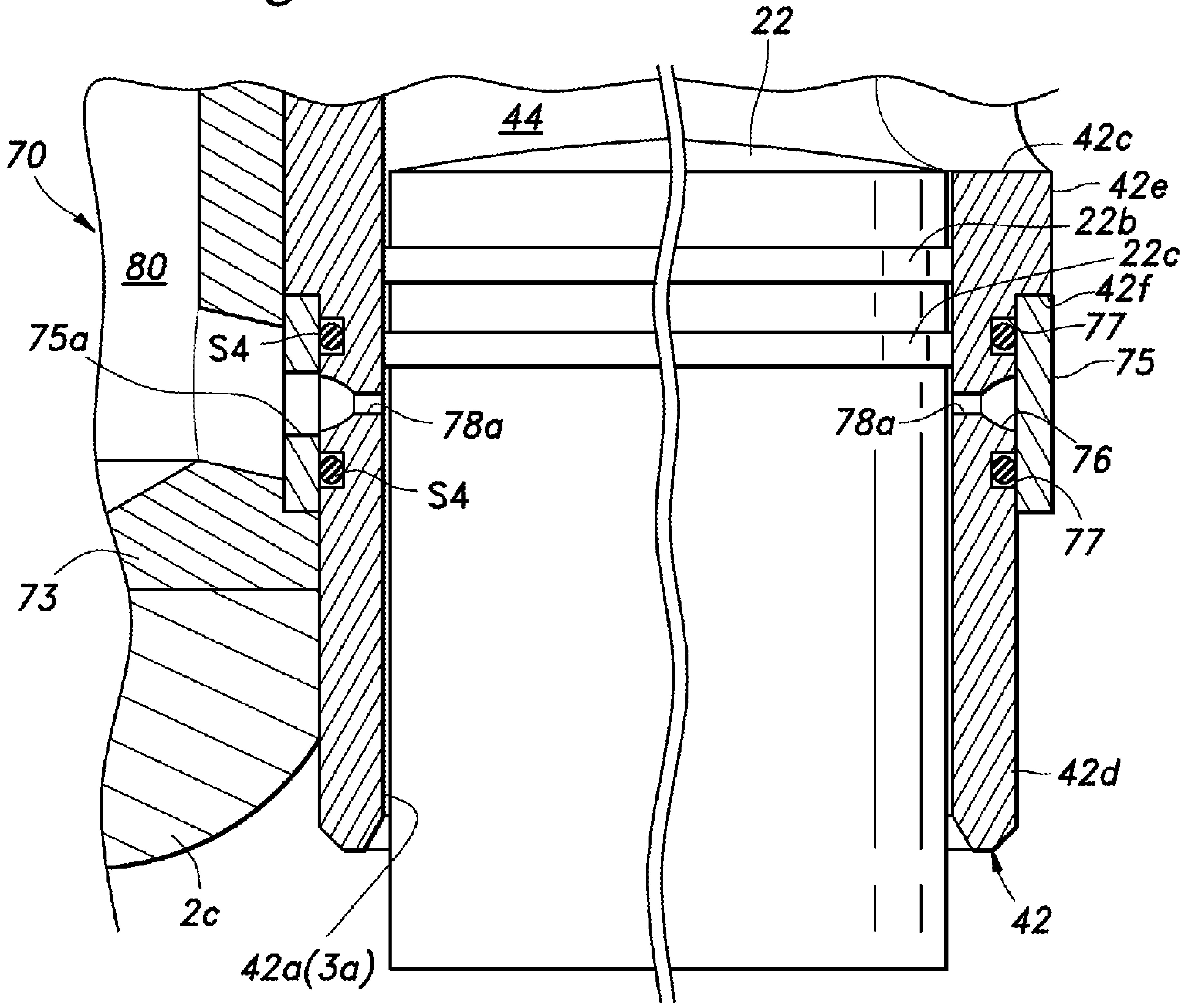

78
76
78
78
78
thrust side
78
anti-thrust side
42a(3a)
78
78
78
78
78
42

Fig. 10


22
44
70
80
42c
42e
22b
22c
42f
77
75
75a
S4
78a
S4
78a
76
77
73
42d
2c
42a(3a)
42

CYLINDER LUBRICATION SYSTEM FOR TWO-STROKE ENGINE

TECHNICAL FIELD

The present invention relates to a cylinder lubrication system for a two-stroke engine, and in particular to a cylinder lubrication system for lubricating between a piston and a cylinder wall by feeding lubricating oil to the cylinder wall from an external lubricating oil source.

BACKGROUND OF THE INVENTION

In a two-stroke engine, the crankcase is enclosed in an air-tight manner so that the intake may be drawn into the crankcase owing to the negative pressure therein created by the upward stroke of the piston, and the air or mixture in the crankcase is compressed by the downward stroke of the piston to be fed into the combustion chamber via a scavenging port which opens up at a certain point of the downward stroke of the piston. Therefore, the splash lubrication which is achieved by the splashing of the lubricating oil received in the crankcase cannot be used, and it is customary to use fuel mixed with two-stroke oil to achieve the required lubrication of the engine.

When the lubrication of the engine relies on the oil mixed in the fuel, the lubricating oil inevitably burns with the fuel so that not only the running cost of the engine is high owing to the high consumption of oil but also undesired emissions increase. External lubrication systems using special piping to feed lubricating oil into the engine from an external source are also known, but in the case of a two-stroke engine involving a crankcase compression, as the lubricating oil that has lubricated by the cylinder inner wall drops into the crankcase to be stirred up by the crank throw and the connecting rod, a significant part of the lubricating oil travels into the combustion chamber to be burnt therein. Therefore, as compared to the engines that are provided with a proper intake valves actuated by a valve actuating mechanism, there still remains the problems of a high lubricating oil consumption and a poor emission property.

As a technology for reducing the consumption of lubricating oil in two-stroke engines using an external source for lubricating the cylinder wall, it is known to provide an oil retaining groove that communicates with each of the oil feed holes opening out in the cylinder wall and extends obliquely in the direction of the scavenging flow swirl. See JP2003-286816A.

As a technology for favorably dispersing lubricating oil on the cylinder wall surface in two-stroke engines for distributing lubricating oil drawn from an external source over the cylinder wall surface, it is known to apply a jet of atomized lubricating oil via a nozzle onto the cylinder wall surface immediately before the piston passes by. See JP2002-529648A.

These prior proposals allow the sliding parts of the piston and the cylinder to be lubricated while reducing the consumption of lubricating oil and undesirable emission. However, in either case, the lubricating oil has to be ejected by using a special oil ejection device at an appropriate timing so that a relatively complex oil feeding system is required, and the manufacturing cost increases Therefore, there is a demand for a lubrication system for small two-stroke engines that is more simple in structure.

SUMMARY OF THE INVENTION

In view of such problems of the prior art, a primary object of the present invention is to provide a cylinder lubrication system for a two-stroke engine which can minimize the consumption of lubricating oil and the emission of undesired substances.

A second object of the present invention is to provide a cylinder lubrication system for a two-stroke engine which is highly simple in structure, but can achieve a favorable lubrication of the cylinder.

To achieve such objects, the present invention provides a cylinder lubrication system for a two-stroke engine including a scavenging port opening out in an inner circumferential surface of a cylinder, comprising: a lubricating oil supply passage defined in an engine main body and connected to a lubricating oil source; and a plurality of lubricating oil supply openings opening out in the inner circumferential surface of the cylinder at a point lower than a top ring of a piston located at a bottom dead center; wherein the lubricating oil supply openings are configured to provide a larger amount of lubricating oil in at least one of a thrust side and an anti-thrust side of the cylinder than in a remaining part of the cylinder.

Thereby, lubricating oil can be supplied to the sliding part between the piston and the cylinder at a proper timing without requiring special oil injection system. In particular, lubricating oil can be supplied to the part that particularly requires lubrication such as a thrust side and an anti-thrust side of the cylinder with an adequate amount without wastefully lubricating other parts of the cylinder, the use efficiency of the lubricating oil can be improved.

Preferably, the lubricating oil supply openings open out in the inner circumferential surface of the cylinder at a point higher than an oil ring of the piston located at a bottom dead center.

Thereby, the lubricating oil supplied from the lubricating oil supply openings can be scraped upward during the upward stroke of the piston so that the lubrication of the sliding part between the piston and the cylinder when the piston is near the top dead center can be performed in a favorable manner.

According to a preferred embodiment of the present invention, the lubricating oil supply openings are arranged circumferentially at a regular interval, those lubricating oil supply openings located on the thrust side and anti-thrust side being greater in diameter than the remaining lubricating oil supply openings.

Thus, the lubricating oil can be preferentially supplied to the thrust side and anti-thrust side of the cylinder by using a simple structure.

According to another preferred embodiment of the present invention, the lubricating oil supply openings are arranged circumferentially, and provided with a same diameter, those lubricating oil supply openings located on the thrust side and anti-thrust side being arranged denser than the remaining lubricating oil supply openings.

In this case also, the lubricating oil can be preferentially supplied to the thrust side and anti-thrust side of the cylinder by using a simple structure.

According to a particularly preferred embodiment of the present invention, the engine main body comprises a cylinder block and a cylinder sleeve fitted in the cylinder block and including a lower end projecting from the cylinder block into a crank chamber, the lubricating oil supply openings being formed in the cylinder sleeve; wherein an annular oil passage forming member surrounds a part of an outer circumferential surface of the cylinder sleeve corresponding to the lubricating oil supply openings, and an annular groove is formed in an inner circumferential surface of the oil passage forming member so as to commonly communicate with the lubricating oil supply openings.

According to this arrangement, an annular oil passage for distributing lubricating oil to the lubricating oil supply openings can be formed simply by installing the annular oil passage forming member which is formed with a groove on the inner circumferential surface thereof around the lower part of the cylinder sleeve. This oil passage is connected to an oil source such as an oil pump so that the lubricating oil may be distributed to the lubricating oil supply openings.

Preferably, an interface between the annular oil passage forming member and the cylinder sleeve is sealed by seal members, both above and below the annular groove.

Thereby, the sealing of the oil passage defined by the annular groove can be achieved in a both simple and reliable manner.

BRIEF DESCRIPTION OF THE DRAWINGS

Now the present invention is described in the following with reference to the appended drawings, in which:

FIG. **1** is a vertical sectional view of an engine embodying the present invention (taken along line I-I of FIG. **2**);

FIG. **2** is a sectional view taken along line II-II of FIG. **1**;

FIG. **3** is a sectional view taken along line III-III of FIG. **2**;

FIG. **4** is a diagram showing the mode of operation of a multiple linkage mechanism used in the engine;

FIG. **5** is an enlarged fragmentary sectional view of a part indicated by V in FIG. **1**;

FIG. **6** is a horizontal sectional view taken along line VI-VI of FIG. **5**;

FIG. **7** is a horizontal section view showing the details of the oil supplying holes shown in FIG. **6**;

FIG. **8** is a view similar to FIG. **6** showing a second embodiment of the present invention;

FIG. **9** is a view similar to FIG. **7** showing the second embodiment of the present invention; and

FIG. **10** is a view similar to FIG. **5** showing a third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The present invention is described in the following with respect to a uni-flow type, single cylinder, two-stroke engine (engine E).

Referring to FIGS. **1** and **2**, an engine main body **1** of the engine E is provided with a crankcase **2** defining a crank chamber **2***a* therein, a cylinder block **3** connected to the upper end of the crankcase **2** and defining a cylinder bore **3***a* therein, a cylinder head **4** connected to the upper end of the cylinder block **3** and a head cover **5** attached to the upper end of the cylinder head **4** to define an upper valve chamber **6** in cooperation with the cylinder head **4**.

The lower most part of the crankcase **2** is provided with an opening **2***b* which conducts the lubricating oil that collects in the bottom part of the crank chamber **2***a* to an oil tank **71** provided outside of the engine main body **1**. An oil pump **72** provided in conjunction with the oil tank **71** supplies the lubricating oil in the oil tank **71** to the sliding part between the piston and the cylinder. The oil tank **71** and the oil pump **72** form a part of a cylinder lubrication system **70** for lubricating the sliding part between the piston and the cylinder. The oil pump **72** may be actuated either by the crankshaft **8** or by an external power source such as an electric motor.

As best shown in FIG. **2**, the crankcase **2** consists of two crankcase halves **7** having a parting plane extending perpendicularly to the crankshaft axial line **8**X and joined to each other by seven threaded bolts **9** (FIGS. **1** and **3**). Each crankcase half **7** includes a side wall **7**S which is provided with an opening through which the corresponding end of a crankshaft **8** projects, and the corresponding end of the crankshaft **8** is rotatably supported by the side wall **7**S via a first bearing B**1**. Thus, the crankshaft **8** is rotatably supported at two ends thereof by the crankcase **2**, and has a crank throw received in the crank chamber **2***a* defined by the crankcase **2**.

The crankshaft **8** includes a pair of journals **11** that are rotatively supported by the first bearings B**1**, respectively, a pair of crank webs **12** extending radially from middle parts of the crankshaft **8**, a crankpin **13** extending between the two webs **12** radially offset from and in parallel with the axial line **8**X of the crankshaft **8**, and a pair of extensions **14** extending coaxially from the outer ends of the journals **11** out of the crankcase **2**. Each crank web **12** is formed as a circular disk defining a larger radius than the outer profile of the crankpin **13** so as to serve as a flywheel that stabilizes the rotation of the crankshaft **8** without substantially splashing the lubricating oil in the crank chamber **2***a*.

Each extension **14** of the crankshaft **8** extends out of the crankcase **2** via a through hole **15** formed in the side wall **7**S of the corresponding crankcase half **7**. The outer side of each ball bearing B**1** is fitted with a seal S**1** to ensure an air tight seal of the crank chamber **2***a*. As shown in FIGS. **2** and **3**, the side wall **7**S of the right crankcase half **7** is integrally formed with a lower valve case **17** protruding therefrom so as to surround the right extension **14** of the crankshaft **8** as seen in FIG. **2**.

The lower valve case **17** is cylindrical in shape with an open outer axial end, and internally defines a lower valve chamber **18**. The opening of the outer end of the lower valve case **17** is closed by a valve chamber lid **19**. The outer axial end of the lower valve case **17** is provided with an annular seal groove **17***a* so that the valve chamber lid **19** may be joined to the opening of the lower valve case **17** in an air tight manner via a second seal member S**2** received in the seal groove **17***a*.

The right end of the crankshaft **8** as seen in FIG. **2** is passed through a through hole **19***a* formed in the valve chamber lid **19**, and extends further outward. The inner circumference of the through hole **19***a* is provided with a third seal member S**3** for ensuring the airtight condition of the lower valve case **17**, and hence the airtight condition of the crank chamber **2***a*.

As shown in FIG. **1**, the central axial line **8**X of the crankshaft **8** or the axial center of the journals **11** is offset from the cylinder axial line **3**X to a side (left side in FIG. **1**). The crankpin **13** rotates around the central axial line **8**X of the crankshaft **8** as the crankshaft **8** rotates, and rotatably supports a middle point of a trigonal link **20** via a tubular portion **20***a* of the trigonal link **20**. A second bearing B**2** is interposed between the crankpin **13** and the tubular portion **20***a*.

The trigonal link **20** includes a pair of plates **20***d* that are joined by the tubular portion **20***a* in a mutually parallel relationship, and a pair of connecting pins (a first connecting pin **20***b* and a second connecting pin **20***c*) fixedly passed between the two plates **20***d*. These connecting pins **20***b* and **20***c* and the crankpin **13** form three pivot points that are arranged in a line at a substantially same interval with the crankpin **13** located in the middle.

The first connecting pin **20***b* located on the side of the cylinder axial line 3X is pivotally connected to a big end **21***a* of a connecting rod **21** via a third bearing B**3**. A small end **21***b* of the connecting rod **21** is pivotally connected to a piston **22** slidably received in the cylinder bore **3***a* via a piston pin **22***a* and a fourth bearing B**4**.

A pivot shaft **23** is fixedly provided in a lower part of the crankcase **2**, on the side remote from the first connecting pin **20***b*. The rotational center lines of the pivot shaft **23** and the three pivot points (**20***a*, **20***b* and **20***c*) are all in parallel to one another. As shown in FIG. **2**, the pivot shaft **23** is press fitted into a pair of mutually opposing holes **24** formed in the two halves of the crankcase **2**, respectively. A base end **25***a* of a swing link **25** is pivotally connected to the pivot shaft **23** via a fifth bearing B**5**. The swing link **25** extends substantially upward from the base end **25***a* thereof, and an upper end or a free end **25***b* of the swing link **25** is pivotally supported by the second connecting pin **20***c* (remote from the cylinder axial line 3X) via a sixth bearing B**6**.

The engine E is thus provided with a multiple link mechanism **30** which includes the trigonal link **20** and the swing link **25** in addition to the connecting rod **21**. The multiple link mechanism **30** converts the linear reciprocating movement of the piston **22** into a rotational movement of the crankshaft **8**. The dimensions and positions of the various components of the multiple link mechanism **30** are selected and arranged such that a prescribed compression ratio selected for the properties of the particular fuel may be achieved. The compression ratio is selected such that the pre-mixed mixture may self-ignite in an appropriate manner. The fuels that may be used for this engine include gasoline, diesel fuel, kerosene, gas (utility gas, LP gas and so on), etc.

Owing to the use of the multiple link mechanism **30**, for the given size of the engine E, the piston stroke L can be maximized so that a larger part of the thermal energy can be converted into kinetic energy, and the thermal efficiency of the engine E can be improved. More specifically, as shown in part (A) of FIG. **4**, when the piston **22** is at the top dead center, the big end **21***a* of the connecting rod **21** which is connected to the first connecting pin **20***b* at the right end of the trigonal link **20** is located higher than the crankpin **13** by a first distance D**1**. Furthermore, as shown in part (B) of FIG. **4**, when the piston **22** is at the bottom dead center, the big end **21***a* of the connecting rod **21** is located lower than the crankpin **13** by a second distance D**2**. Therefore, as compared to the conventional engine where the big end **21***a* of the connecting rod **21** is directly connected to the crankpin **13**, the piston stroke L can be extended by the sum of these two distances or by D**1**+D**2**. Therefore, the piston stroke L of the engine E can be extended without increasing the size of the crankcase **2** or the overall height of the engine E.

In this engine E, the trajectory T of the big end **21***a* of the connecting rod **21** is vertically elongated, instead of being truly circular, as shown in (A) and (B) of FIG. **4**. In other words, as compared to the more conventional reciprocating engine having the constant crank radius R, the swing angle of the connecting rod **21** is reduced. Therefore, the interferences between the lower end of the cylinder (or lower end of the cylinder sleeve **42**) and the connecting rod **21** can be avoided even when the cylinder bore **3***a* is relatively small. Furthermore, the reduction in the swing angle of the connecting rod **21** contributes to the reduction in the thrust loads which the piston **22** applies to the two sides (thrust side and anti-thrust side) of the cylinder wall.

As shown in FIG. **1**, the crank chamber **2***a* is laterally extended in the region of the swing link **25** and is vertically extended in the region directly under the piston **22** so that the trigonal link **20** that undergoes a composite rotational movement, the swing link **25** that undergoes a swinging movement and the connecting rod **21** that undergoes a vertically elongated circular movement may not interfere with one another. The part of the crankcase **2** adjoining the lower end of the cylinder bore **3***a* is formed with a cylindrical recess **31** having a circular cross section (taken along a horizontal plane) substantially coaxial with the cylinder bore **3***a* and surrounding the lower end of the cylinder sleeve **42** such that an annular space communicating with the crank chamber **2***a* is defined around the lower end of the cylinder sleeve **42**. In FIG. **1**, the piston **22** at the bottom dead center is indicated by imaginary lines.

The cylindrical recess **31** is provided with a greater inner diameter than the outer diameter of the lower part of the cylinder sleeve **42**, and a retaining portion **2***c* formed in the crankcase **2** projects into an outer peripheral part of the cylindrical recess **31**. The retaining portion **2***c* retains a first oil passage forming member **73** which defines an oil passage for supplying lubricating oil to the sliding part between the piston and the cylinder. Owing to the presence of the retaining portion **2***c*, a C-shaped space communicating with the crank chamber **2***a* is defined around the lower part of the cylinder sleeve **42**. The first oil passage forming member **73** is provided with an oil passage **73***a* including an outlet that opens out at the inner circumferential surface of the cylinder sleeve **42** at a same position as an oil passage **75***a* of a third oil passage forming member **75** (which will be described hereinafter). The upstream end of the oil passage **73***a* of the first oil passage forming member **73** is connected to an oil passage **80** formed in the cylinder block **3**. A second oil passage forming member **74** is fitted into a side wall of the cylinder block **3** to serve as a fluid coupling (internally defining an oil inlet passage) that conducts the oil supplied by the oil pump **72** into the oil passage **80** formed in the cylinder block **3**. Thus, the lubricating oil feed by the oil pump **72** is introduced into the oil passage **80** formed in the cylinder block **3** via the oil inlet passage defined in the second oil passage forming member **74**, and is then passed into the oil passage **73***a* of the first oil passage forming member **73** and the oil passage **75***a* of the third oil passage forming member **75**.

An intake port **32** is formed by a tubular extension of the crankcase **2** extending obliquely upward adjacent to the first oil passage forming member **73** in the upper part of the crankcase **2**. The intake port **32** is fitted with a reed valve **33** that permits the flow of air from the intake port **32** to the crank chamber **2***a*, and prohibits the flow of air in the opposite direction. The reed valve **33** includes a base member **33***a* consisting of a wedge shaped member having a pointed end directed inward and a pair of openings defined on either slanted sides thereof, a pair of valve elements **33***b* mounted on the base member **33***a* so as to cooperate with the openings thereof and a pair of stoppers **33***c* placed on the backsides of the valve elements **33***b* so as to limit the opening movement of the valve elements **33***b* within a prescribed limit. The reed valve **33** is normally closed, and opens when the piston **22** moves upward and the internal pressure in the crank chamber **2***a* thereby drops.

To the outer end of the intake port **32** is connected a throttle body **34** so as to define an intake passage **34***a* extending vertically as a smooth continuation of the intake port **32**. A throttle valve **34***b* is pivotally mounted on a horizontal shaft for selectively closing and opening the intake passage **34***a*. A fuel injector **35** is also mounted on the throttle body **34** with an injection nozzle **35***a* thereof directed into a part of the intake passage **34***a* somewhat downstream of the throttle valve **34***b*. The axial line of the fuel injector **35** is disposed obliquely so as to be directed to the reed valve **33**, and fuel is injected into the intake passage **34***a* in synchronism with the opening of the reed valve **33**. The upstream end of the throttle body **34** is connected to an L shaped intake pipe **36** including a vertical section connected to the throttle body **34** and a horizontal section extending away from the cylinder block **3**.

Four stud bolts **38** are secured to the upper side of the crankcase **2** and extend upward around the cylinder bore **3***a* at a regular interval as can be seen from FIG. **1**. The cylinder block **3** and the cylinder head **4** are secured to the crankcase **2** by passing the stud bolts **38** therethrough and threading acorn nuts **39** onto the upper ends of the stud bolts **38**.

As shown in FIGS. **1** and **2**, the cylinder block **3** is provided with a bore **41** having a circular cross section passed therethrough, and the cylinder sleeve **42** is fitted into this bore **41** with the lower end thereof extending into the cylindrical recess **31** mentioned above. The bore **41** is provided with a large diameter section **41***b* in an upper end thereof defining an annular shoulder **41***a* facing upward, and the cylinder sleeve **42** is provided with a radial flange **42***b* configured to rest on this annular shoulder **41***a*. The upper end part of the cylinder sleeve **42** (or the part thereof located above the radial flange **42***b*) defines an annular space **41***b* in cooperation with the large diameter section **41***b* of the bore **41** of the cylinder block **3**.

The cylinder sleeve **42** is provided with a constant inner diameter over the entire length thereof except for the lower end thereof which is chamfered, and the cylinder bore **3***a* is defined by an inner circumferential surface **42***a* of the cylinder sleeve **42**. The outer diameter of the cylinder sleeve **42** is also constant over the entire length thereof except for the lower end thereof which is reduced in diameter over a certain length and a part adjacent to the upper end thereof which is provided with the radial flange **42***b* defining an annular shoulder surface abutting the annular shoulder **41***a* to determine the axial position of the cylinder sleeve **42** relative to the cylinder block **3**. The upper end of the cylinder sleeve **42** is flush with the upper end surface of the cylinder block **3**, and the cylinder sleeve **42** is provided with a somewhat greater vertical dimension than the cylinder block **3** so that the lower end of the cylinder sleeve **42** projects out of the lower end of the cylinder block **3** into the cylindrical recess **31** of the crankcase **2**.

The front and rear sides of the lower part of the cylinder sleeve **42** is provided with three scavenging orifices **42***c* at the regular interval of 120 degrees each having an upper edge located somewhat higher than the interface between the cylinder block **3** and the crankcase **2**. The three scavenging orifices **42***c* are identical in shape and dimensions, and are located at the same elevation. As shown in FIGS. **1** and **2**, each scavenging orifice **42***c* consists of a pair of rectangular openings separated by a vertical bar and positioned laterally next to each other.

As shown in FIG. **1**, the part of the cylinder block **3** opposing each scavenging orifice **42***c* is formed with a recess **3***b* defined by a curved wall surface which is configured to guide the mixture from the crank chamber **2***a* smoothly into the scavenging orifices **42***c*. In other words, each scavenging orifice **42***c* and the corresponding recess **3***b* jointly form a scavenging port **43** that communicates the crank chamber **2***a* and the cylinder bore **3***a* with each other via the cylindrical recess **31**. In particular, each scavenging port **43** communicates the crank chamber **2***a* and the cylinder bore **3***a* (or the combustion chamber **44** thereof defined above the piston **22**) via the cylindrical recess **31** during a late part of the downward stroke of the piston **22** and an early part of the upward stroke of the piston **22** so that the scavenging port is opened and closed by the piston **22** as the piston **22** moves up and down.

The lower part of the cylinder sleeve **42** which projects into the cylindrical recess **31** and located below the scavenging orifices **42***c* is closely surrounded with the third oil passage forming member **75** consisting of an annular band. FIG. **5** is an enlarged view of the part indicated by V in FIG. **1** when the piston **22** is at the bottom dead center. As shown in FIG. **5**, a pair of annular grooves are formed around the upper part of the piston **22** which receive a compression ring (top ring) **22***b* and an oil ring **22***c*, respectively. The third oil passage forming member **75** is fitted on a small diameter portion **42***d* in the lower end part of the cylinder sleeve **42** such that the upper surface of the third oil passage forming member **75** abuts an annular shoulder surface **42***f* defined between the small diameter portion **42***d* and the remaining part of the cylinder sleeve **42** (or a large diameter portion **42***e* thereof). The third oil passage forming member **75** is provided with a substantially same outer diameter as the large diameter portion **42***e* of the cylinder sleeve **42** so that the continuous outer circumferential surface is defined by these two members. The part of the third oil passage forming member **75** is formed with a through hole serving as an oil passage **75***a* corresponding to the oil passage **73***a* of the first oil passage forming member **73** which in turn communicates with the oil passage **80** formed in the cylinder block **3**.

The outer circumferential surface of the small diameter portion **42***d* of the cylinder sleeve **42** is provided with an annular groove **76** at a height corresponding to the oil passage **75***a* of the third oil passage forming member **75**. The annular groove **76** is closely surrounded by the third oil passage forming member **75** so as to define an annular oil passage. The outer circumferential surface of the small diameter portion **42***d* of the cylinder sleeve **42** is further provided with a pair of annular seal grooves **77**, one above the annular groove **76** and the other below the annular groove **76**, for receiving O-rings or fourth seal member S4 for sealing the annular groove **76** in cooperation with the third oil passage forming member **75**. The cylinder sleeve **42** is formed with a number of oil supply holes **78** (**78***a*-**78***c*) that are located lower than the compression ring **22***b* and higher than the oil ring **22***c* when the piston **22** is at the bottom dead center, and communicates the annular groove **76** with the interior of the cylinder sleeve **42**. The oil supply holes **78** extend horizontally and radially and open out in the interior of the cylinder sleeve **42** at the same height as the annular groove **76**. The oil supply holes **78** and the various oil passages **73***a*, **75***a*, **80** jointly form a cylinder lubrication system **70** for lubricating the sliding part between the piston and the cylinder.

As shown in FIG. **6**, the oil passages **73***a* and **75***a* of the first and third oil passage forming members **73** and **75** are placed at a position offset or at an angle from the direction perpendicular to the piston pin **22***a* (the thrust/anti-thrust direction). On the other hand, the oil supply holes **78** are provided at eight locations at a circumferentially regular interval (45 degrees) including two of them that are located in the thrust/anti-thrust direction. In the illustrated embodiment, the oil passage **75***a* opens into the annular groove **76** at a point that does not align with any of the oil supply holes **78** to minimize any even distribution of the lubricating oil to the oil supply holes **78**.

The two oil supply holes (first oil supply holes) **78***a* that are located in the thrust/anti-thrust direction have a diameter d**1**, the two oil supply holes (second oil supply holes) **78***b* that are located in the piston pin direction have a diameter d2, and the remaining four oil supply holes (third oil supply holes) **78***c* have a diameter d**3**, these diameters being dimensioned such that d1>d2>d3. In other words, those oil supply holes **78***a* located in the thrust/anti-thrust direction have a greater inner diameter than those of the other oil supply holes **78***b* and **78***c*.

Therefore, the lubricating oil supplied from the pump **72** is forwarded to the oil supply holes **78** via the oil passages **80**, **73***a* and **75***a* and the annular groove **76**. In particular, a relative large amount of oil is supplied to the cylinder bore **3***a* via each first lubricating oil supply holes **78***a* located in the thrust/anti-thrust direction, and a relatively small amount of oil is supplied to the cylinder bore **3***a* via each second lubricating oil supply holes **78***b*. An even smaller amount of oil is supplied to the cylinder bore **3***a* via each third lubricating oil supply holes **78***c*. The lubricating oil is deposited on the outer circumferential surface of the piston **22** when the piston **22** is near the bottom dead center thereof, and when the piston **22** has reached the bottom dead center thereof, the lubricating oil is deposited in the region of the outer circumferential surface of the piston **22** located between the compression ring **22***b* and the oil ring **22***c*. The lubricating oil that has deposited on the outer circumferential surface of the piston **22** is pulled upward in the cylinder bore **3***a* during the upward stroke of the piston **22**, and provides a lubrication to the sliding part between the piston and the inner circumferential surface **42***a* of the cylinder sleeve **42**. In particular, the lubricating oil that has deposited on the region of the outer circumferential surface of the piston **22** located between the compression ring **22***b* and the oil ring **22***c* is actively pulled upward by the scraping action of the oil ring **22***c*, and provides a favorable lubrication between the piston **22** and the cylinder sleeve **42** even when the piston **22** is near the top dead center thereof. The lubricating oil that has dropped under the gravitation force or scraped downward by the piston **22** is collected in the bottom part of the crank chamber **2***a*, and flows into the oil tank **71** via the opening **2***b* of the crankcase **2**.

As shown in FIGS. **1** and **2**, the part of the lower surface of the cylinder head **4** corresponding to the cylinder bore **3***a* is recessed in a dome-shape (dome-shaped recess **4***a*) so as to define a combustion chamber **44** jointly with the top surface of the piston **22**. An annular groove **4***b* is formed in the lower surface of the cylinder head **4** concentrically around the dome-shaped recess **4***a* which aligns with the annular recess **41***b* defined between the upper part of the cylinder sleeve **42** and the surrounding wall of the cylinder block **3** such that a water jacket **45** surrounding the dome-shaped recess **4***a* of the cylinder head **4** and the upper part of the cylinder bore **3***a* is defined jointly by the annular recess **41***b* and the annular groove **4***b*.

The cylinder head **4** is further provided with an exhaust port **46** opening out at the top end of the combustion chamber **44** and a plug hole for receiving a spark plug **47** therein. In the illustrated embodiment, the spark plug **47** is normally activated only at the time of starting the engine to ignite the mixture in the combustion chamber **44**. The exhaust port **46** is provided with an exhaust valve **48** consisting of a poppet valve to selectively close and open the exhaust port **46**. The exhaust valve **48** includes a valve stem which is slidably guided by the cylinder head **4** at an angle to the cylinder axial line 3X, and the stem end of the exhaust valve **48** extends into the upper valve chamber **6** containing a part of the valve actuating mechanism **50** for actuating the exhaust valve **48** via the stem end thereof.

The valve actuating mechanism **50** includes a valve spring **51** that resiliently urges the exhaust valve **48** in the closing direction (upward), an upper rocker shaft **53** supported by a block **52** provided on the cylinder head **4** and an upper rocker arm **54** rotatably supported by the upper rocker shaft **53**. The upper rocker shaft **53** extends substantially perpendicularly to the crankshaft **8**, and the upper rocker arm **54** extends substantially in parallel to the crankshaft **8**. One end of the upper rocker arm **54** is provided with a socket **54***a* engaging the upper end **55***a* of the pushrod **55**, and the other end of the upper rocker arm **54** is provided with a tappet adjuster **54***b* consisting of the screw which engages the stem end of the exhaust valve **48**. The upper end **55***a* of the pushrod **55** is given with a semi-spherical shape, and the socket **54***a* of the rocker arm **54** receives the upper end **55***a* of the pushrod **55** in a complementary manner, allowing a certain sliding movement between them.

As shown in FIGS. **2** and **3**, the pushrod **55** extends substantially vertically along a side of the cylinder block **3**, and is received in a tubular rod case **56** having an upper end connected to the cylinder head **4** and a lower end connected to the lower valve case **17**. In the illustrated embodiment, the rod case **56** extends along the exterior of the cylinder block **3**.

Because the crankshaft **8** is offset from the cylinder axial line 3X (FIG. **1**), as best shown in FIG. **3**, the lower end of the rod case **56** is connected to a part of the upper wall of the lower valve case **17** laterally offset from the crankshaft **8**. The lower valve chamber **18** receives the remaining part of the valve actuating mechanism **50**. The lower wall of the lower valve case **17** is provided with a drain hole **57** for expelling the lubricating oil in the lower valve chamber **18** which is usually closed by a drain plug **58**.

The valve actuating mechanism **50** further comprises a cam **61** carried by the part of the crankshaft **8** extending into the lower valve chamber **18**, a lower rocker shaft **63** supported by the side wall 7S of the crankcase **2** and the valve chamber lid **19** in parallel with the crankshaft **8** and a lower rocker arm **64** pivotally supported by the lower rocker shaft **63** for cooperation with the cam **61**. In other words, one of the extensions **14** of the crankshaft **8** (the right end thereof in FIG. **2**) serves as the camshaft **66** for the cam **61**.

As shown in FIG. **3**, the lower rocker arm **64** includes a tubular portion **64***a* rotatably supported by the lower rocker shaft **63**, a first arm **64***b* extending from the tubular portion **64***a* toward the crankshaft **8**, a roller **64***c* pivotally supported by the free end of the first arm **64***b* to make a rolling contact with the cam **61**, a second arm **64***d* extending from the tubular portion **64***a* away from the first arm **64***b*, and a receiving portion **64***e* formed in the free end of the second arm **64***d* to support the lower end **55***b* of the pushrod **55**. The lower end of the pushrod **55** is given with a semi-spherical shape, and the receiving portion **64***e* is formed as a recess complementary to the semi-spherical lower end of the pushrod **55** so as to receive the lower end of the pushrod **55** in a mutually slidable manner.

The engine E described above operates as described in the following at the time of start-up. Referring to FIG. **1**, in the upward stroke of the piston **22**, owing to the depressurization of the crank chamber **2***a*, the reed valve **33** opens. As a result, a mixture of the fresh air metered by the throttle valve **34***b* and the fuel injected into this fresh air by the fuel injector **35** is drawn into the crank chamber **2***a* via the reed valve **33** and the intake port **32**. Meanwhile, the mixture in the cylinder bore **3***a* is compressed by the piston **22**, and is ignited by the spark from the spark plug **47** when the piston **22** is near the top dead center.

The piston **22** then undergoes a downward stroke, and because the reed valve **33** is closed at this time, the mixture in the crank chamber **2***a* is prevented from flowing back to the throttle valve **34***b*, and compressed. During the downward stroke of the piston **22**, before the piston **22** opens the scavenging port **43**, the exhaust valve **48** actuated by the valve actuating mechanism **50** according to the cam profile of the cam **61** opens the exhaust port **46**. Once the piston **22** opens the scavenging port **43**, the compressed mixture is introduced into the cylinder bore **3***a* (combustion chamber **44**) via the scavenging port **43**. The combustion gas in the combustion chamber **44** is displaced by this mixture, and is expelled from the exhaust port **46** while part of the combustion gas remains in the combustion chamber **44** as EGR gas. The valve opening timing of the exhaust valve **48** is determined such that the amount of the EGR gas remaining in the combustion chamber **44** is great enough for the self-ignition of the mixture to take place owing to the rise in the temperature of the mixture in the combustion chamber **44** under compression with the increase in the amount of the EGR gas.

When the piston **22** undergoes an upward stroke once again, the piston **22** closes the scavenging port **43**, and, thereafter, the exhaust valve **48** actuated by the first cam **61** closes the exhaust port **46**. As a result, the mixture in the cylinder bore **3***a* (combustion chamber **44**) is compressed while the crank chamber **2***a* is depressurized, causing the mixture to be drawn thereinto via the reed valve **33**. Once the engine E is brought into a stable operation, the mixture is self-ignited as the piston **22** comes near the top dead center, and the combustion gas created by the resulting combustion pushes down the piston **22**.

The engine E thus performs a two-stroke operation. In particular, spark ignition using the spark plug **47** is required at the time of start up, but once the engine starts operating in a stable manner, a two-stroke operation based on a homogeneous charge compression ignition is performed. The scavenging flow from the scavenging port **43** to the exhaust port **46** via the cylinder bore **3***a* is guided along a relatively straight path, or the so-called "uni-flow scavenging" can be achieved.

In the illustrated embodiment, the oil passage **80** connected to the oil pump **72** is formed in the cylinder block **3**, and the oil supply holes **78** that communicate with the oil passage **80** and open out in the upper part of the cylinder bore **3***a* which is above the oil ring **22***c* and/or below the compression ring **22***b* are formed in the cylinder sleeve **42** when the piston **22** is at the bottom dead center so that the lubricating oil is favorably supplied to the sliding part between the piston **22** and the cylinder sleeve **42**. Thus, the sliding resistance to the piston **22** is minimized, and the seizing of the piston **22** can be avoided in a reliable manner. Furthermore, such a lubrication can be accomplished by using a highly simple structure.

Particularly when the oil supply holes **78** open out in the upper part of the cylinder bore **3***a* which is above the oil ring **22***c* and/or below the compression ring **22***b* are formed in the cylinder sleeve **42** when the piston **22** is at the bottom dead center, the supplied lubricating oil is scraped upward by the oil ring **22***c* during the upward stroke of the piston **22** so that the lubrication of the sliding part between the piston **22** and the cylinder sleeve **42** when the piston **22** is near the top dead center can be performed in a highly favorable manner.

In the illustrated embodiment, because the thrust and anti-thrust sides of the cylinder bore **3***a* receive relatively large amounts of lubricating oil while the remaining parts receive relatively small amounts of lubricating oil, the parts involving greater frictions are favorably lubricated, and the parts involving smaller frictions are prevented from receiving excessive amounts of lubricating oil so that the use efficiency of lubricating oil can be optimized.

In the illustrated embodiment, as the oil supply holes **78** are arranged along the circumferential direction at a regular internal, and the diameter d**1** of the first oil supply holes **78***a* located on the thrust and anti-thrust sides of the cylinder bore **3***a* is greater than the diameters d**2** and d**3** of the remaining oil supply holes **78***b* and **78***c*, relatively larger amounts of lubricating oil are supplied to the thrust and anti-thrust sides of the cylinder bore **3***a*. Thus, the thrust and anti-thrust sides of the cylinder bore **3***a* which are subjected to relatively high loadings are allowed to be preferentially lubricated simply by varying the sizes of the oil supply holes **78**.

In the illustrated embodiment, the engine main body **1** comprises the cylinder block **3**, the cylinder sleeve **42** fitted in the cylinder block **3** and having a lower end projecting from the cylinder block **3** into the crank chamber **2***a* and the annular third oil passage forming member **75** around the small diameter portion **42***d* of the cylinder sleeve **42** projecting into the crank chamber **2***a* such that the oil passage may be formed by the annular groove **76** formed around the small diameter portion **42***d* to distribute the lubricating oil supplied from the oil passage **80** defined in the cylinder block **3** to the lubricating oil supply holes **78** formed in the small diameter portion **42***d* of the cylinder sleeve **42**.

Thereby, the oil passage for the distribution of lubricating oil can be fabricating in a highly simple manner. Because the annular third oil passage forming member **75** is fitted around the small diameter portion **42***d* of the cylinder sleeve **42** projecting into the crank chamber **2***a*, it is possible to assemble the third oil passage forming member **75** either before or after the third oil passage forming member **75** is installed in the cylinder block **3**. In either case, the assembled state of the third oil passage forming member **75** can be inspected after the third oil passage forming member **75** is installed in the cylinder block **3**.

The interface between the cylinder sleeve **42** and the third oil passage forming member **75** is sealed, both above and below, by the fourth seal members S**4** received in the annular groove **76**, and this provides a highly simple and reliable sealing performance.

Optionally, a one-way valve may be provided in the first oil passage forming member **73** of the second oil passage forming member **74** to prevent the mixture placed under pressure in the crank chamber **2***a* from flowing into the oil passages and blocking the supply of lubricating oil. It is also possible to provide a flow restricting orifice in any of these oil passage forming members to adjust the amount of lubricating oil to be supplied. A cut valve may be provided in any part of the oil passages to shut off the supply of lubricating oil when the engine is not in operation.

A second embodiment of the present invention is described in the following with reference to FIGS. **8** and **9**. In the following description, the parts corresponding to those of the previous embodiment are denoted with like numerals without necessarily repeating the description of such parts.

As shown in FIGS. **8** and **9**, there are twelve lubricating oil supply holes **78**, and all of the lubricating oil supply holes **78** have a same diameter. In this case, the interval between the adjoining lubricating oil supply holes **78** is smaller in the thrust and anti-thrust sides of the cylinder bore **3***a* is smaller than that in the piston pin sides. In other words, the lubricating oil supply holes **78** are more densely provided in the thrust and anti-thrust sides of the cylinder bore **3***a* than in the piston pin sides. More specifically, three of the lubricating oil supply holes **78** are grouped in each of the thrust and anti-thrust sides at an interval of 15 degrees, and the remaining lubricating oil supply holes **78** are arranged at the regular interval of 45 degrees. Again, the oil passage **75***a* opens into the annular groove **76** at a point that does not align with any of the oil supply holes **78** to minimize any even distribution of the lubricating oil to the oil supply holes **78**.

Therefore, a relative large amount of oil is supplied to the cylinder bore **3***a* via the first lubricating oil supply holes **78** located in the thrust/anti-thrust direction, and a relatively small amount of oil is supplied to the cylinder bore **3***a* via the remaining lubricating oil supply holes **78**. The lubricating oil is deposited on the outer circumferential surface of the piston **22** when the piston **22** is near the bottom dead center thereof, and when the piston **22** has reached the bottom dead center thereof, the lubricating oil is deposited in the region of the outer circumferential surface of the piston **22** located between the compression ring **22***b* and the oil ring **22***c*. The lubricating oil that has deposited on the outer circumferential surface of the piston **22** is pulled upward in the cylinder bore **3***a* during the upward stroke of the piston **22**, and provides a favorable lubrication to the sliding part between the piston and the inner circumferential surface **42***a* of the cylinder sleeve **42**.

Thus, according to the second embodiment of the present invention, because the lubricating oil supply holes **78** are more densely provided in the thrust and anti-thrust sides of the cylinder bore **3***a* than in the piston pin sides, the thrust and anti-thrust sides are more preferentially lubricated. This embodiment is advantageous simplifying the manufacturing process because the lubricating oil supply holes **78** may have a same diameter.

A third embodiment of the present invention is described in the following with reference to FIG. **10**. In the following description, the parts corresponding to those of the previous embodiments are denoted with like numerals without necessarily repeating the description of such parts.

FIG. **10** is a view similar to FIG. **5** showing an essential part of the engine E when the piston is at the bottom dead center. In this embodiment, the annular groove **76** and the lubricating oil supply holes **78** are provided immediately below the oil ring **22***c* or the lower most ring when the piston **22** is at the bottom dead center. In this case also, the lubricating oil that has deposited on the outer circumferential surface of the piston **22** during the downward stroke thereof is pulled upward as the piston **22** moves upward so that the interface between the outer circumferential surface of the piston **22** and the inner circumferential surface of the cylinder sleeve can be lubricated in a favorable manner during the entire stroke of the piston **22**.

In the illustrated embodiments, the present invention was applied to an OHV, uni-flow type, two-stroke engine where the exhaust valve **48** is provided in the cylinder head **4**. However, the present invention is equally applicable to more common two-stroke engines where the exhaust port opens out in the inner circumferential surface of the cylinder sleeve **42**, instead of the exhaust valve **48** in the cylinder head **4**. in the foregoing embodiments, the lubricating oil recovered from the crank chamber **2***a* was stored in the oil tank **71**, and fed to the cylinder sleeve **42** by the oil pump **72**. However, it is also possible to use a lubrication oil supply system for feeding lubricating oil to the valve actuating mechanism **50** for supplying lubricating oil to the cylinder sleeve. The annular groove **76** and the seal grooves **77** were formed in the outer circumferential surface of the cylinder sleeve **42**, but may also be formed in the inner circumferential surface of the third oil passage forming member **75**.

Although the present invention has been described in terms of preferred embodiments thereof, it is obvious to a person skilled in the art that various alterations and modifications are possible without departing from the scope of the present invention which is set forth in the appended claims.

The contents of the original Japanese patent application on which the Paris Convention priority claim is made for the present application as well as the contents of the prior art references mentioned in this application are incorporated in this application by reference.

The invention claimed is:

1. A cylinder lubrication system for a two-stroke engine including a scavenging port opening out in an inner circumferential surface of a cylinder, comprising:

a lubricating oil supply passage defined in an engine main body and connected to a lubricating oil source; and

a plurality of lubricating oil supply openings opening out in the inner circumferential surface of the cylinder at a point lower than a top ring of a piston located at a bottom dead center, the piston being connected to a connecting rod by a piston pin;

wherein portions of the inner circumferential surface of the cylinder which are disposed on a line perpendicular to a longitudinal direction of the piston pin are a thrust side and an antithrust side of the inner circumferential surface of the cylinder,

wherein the engine main body comprises a cylinder block and a cylinder sleeve fitted in the cylinder block, the lubricating oil supply openings being formed in the cylinder sleeve and an annular oil passage that communicates the lubricating oil supply passage with the plurality of lubricating oil supply openings being defined on an outer circumferential surface of the cylinder sleeve,

wherein the lubricating oil supply openings are arranged circumferentially,

wherein, at at least one axial position of the cylinder, the lubricating oil supply openings located nearest to the thrust side and the anti-thrust side are greater in diameter than the lubricating oil supply openings located nearest to portions of the inner circumferential surface of the cylinder which are disposed on a line extending in the longitudinal direction of the piston pin,

wherein the cylinder sleeve includes a lower end projecting from the cylinder block into a crank chamber, the lubricating oil supply openings being formed in the lower end of the cylinder sleeve projecting from the cylinder block into the crank chamber; and

wherein an annular oil passage forming member surrounds a part of the outer circumferential surface of the cylinder sleeve corresponding to the lubricating oil supply openings, and an annular groove serving as the annular oil passage is formed between an inner circumferential surface of the oil passage forming member and the outer circumferential surface of the cylinder sleeve so as to commonly communicate with the lubricating oil supply openings.

2. The cylinder lubrication system for a two-stroke engine according to claim **1**, wherein the lubricating oil supply openings open out in the inner circumferential surface of the cylinder at a point higher than an oil ring of the piston located at a bottom dead center.

3. A cylinder lubrication system for a two-stroke engine including a scavenging port opening out in an inner circumferential surface of a cylinder, comprising:

a lubricating oil supply passage defined in an engine main body and connected to a lubricating oil source; and

a plurality of lubricating oil supply openings opening out in the inner circumferential surface of the cylinder at a point lower than a top ring of a piston located at a bottom dead center, the piston being connected to a connecting rod by a piston pin;

wherein portions of the inner circumferential surface of the cylinder which are disposed on a line perpendicular to a longitudinal direction of the piston pin are a thrust side and an antithrust side of the inner circumferential surface of the cylinder,

wherein the engine main body comprises a cylinder block and a cylinder sleeve fitted in the cylinder block, the lubricating oil supply openings being formed in the cylinder sleeve and an annular oil passage that communicates the lubricating oil supply passage with the lubricating oil supply openings being defined on an outer circumferential surface of the cylinder sleeve,

wherein the lubricating oil supply openings are arranged circumferentially and are provided with a same diameter,

wherein, at at least one axial position of the cylinder, the lubricating oil supply openings located nearest to the thrust side and the anti-thrust side are arranged at a higher density than the lubricating oil supply openings located nearest to portions of the inner circumferential surface of the cylinder which are disposed on a line extending in the longitudinal direction of the piston pin,

wherein the cylinder sleeve includes a lower end projecting from the cylinder block into a crank chamber, the lubricating oil supply openings being formed in the lower end of the cylinder sleeve projecting from the cylinder block into the crank chamber; and

wherein an annular oil passage forming member surrounds a part of the outer circumferential surface of the cylinder sleeve corresponding to the lubricating oil supply openings, and an annular groove serving as the annular oil passage is formed between an inner circumferential surface of the oil passage forming member and the outer circumferential surface of the cylinder sleeve so as to commonly communicate with the lubricating oil supply openings.

4. The cylinder lubrication system for a two-stroke engine according to claim **1**, wherein an interface between the annular oil passage forming member and the cylinder sleeve is sealed by seal members, both above and below the annular groove.

5. The cylinder lubrication system for a two-stroke engine according to claim **3**, wherein the lubricating oil supply openings open out in the inner circumferential surface of the cylinder at a point higher than an oil ring of the piston located at a bottom dead center.

6. The cylinder lubrication system for a two-stroke engine according to claim **3**, wherein an interface between the annular oil passage forming member and the cylinder sleeve is sealed by seal members, both above and below the annular groove.

7. A cylinder lubrication system for a two-stroke engine including a scavenging port opening out in an inner circumferential surface of a cylinder, comprising:

a lubricating oil supply passage defined in an engine main body and connected to a lubricating oil source; and

a plurality of lubricating oil supply openings opening out in the inner circumferential surface of the cylinder at a point lower than a top ring of a piston located at a bottom dead center, the piston being connected to a connecting rod by a piston pin;

wherein the engine main body comprises a cylinder block and a cylinder sleeve fitted in the cylinder block, the lubricating oil supply openings being formed in the cylinder sleeve and an annular oil passage that communicates the lubricating oil supply passage with the plurality of lubricating oil supply openings being defined on an outer circumferential surface of the cylinder sleeve,

wherein the lubricating oil supply openings are arranged circumferentially,

wherein the cylinder sleeve includes a lower end projecting from the cylinder block into a crank chamber, the lubricating oil supply openings being formed in the lower end of the cylinder sleeve projecting from the cylinder block into the crank chamber, and

wherein an annular oil passage forming member surrounds a part of the outer circumferential surface of the cylinder sleeve corresponding to the lubricating oil supply openings, and an annular groove serving as the annular oil passage is formed between an inner circumferential surface of the oil passage forming member and the outer circumferential surface of the cylinder sleeve so as to commonly communicate with the lubricating oil supply openings.

* * * * *